



# INTERNATIONAL SPACE STATION AND ROBOTICS

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NASA Advisory Council/Human Exploration and Operations Committee  
7 March, 2012



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NASA Headquarters  
Washington, DC

# AGENDA



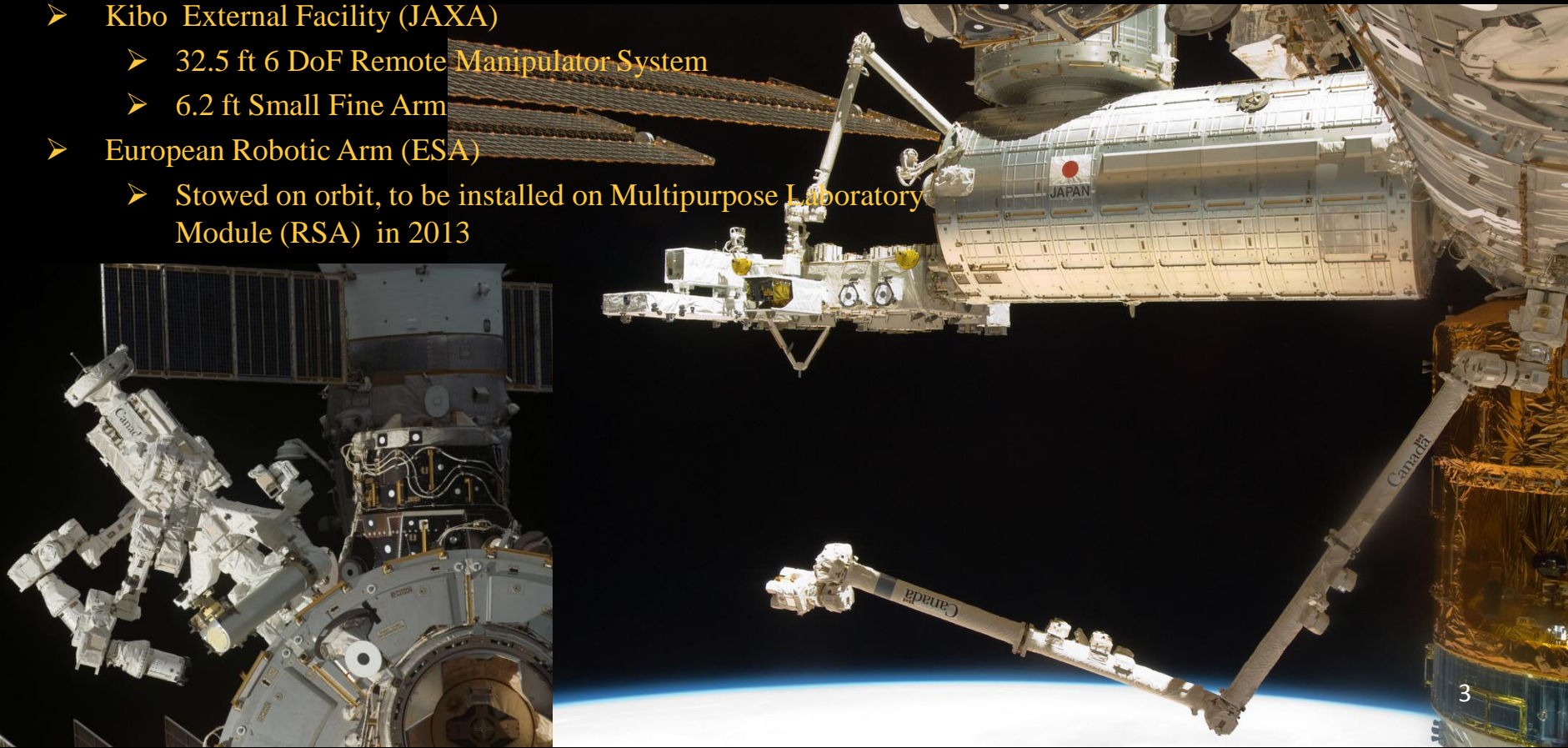
- ISS Robotics Systems Overview
- Robotics Research and Technology Demonstrations on ISS
- Future Concepts



# ISS Robotic Systems Overview



- Mobile Servicing System (CSA)
  - 57 ft, 7 DoF Space Station Remote Manipulator System
  - 11.4 ft, 2 armed - 6 DoF Special Purpose Dexterous Manipulator “Dextre”
  - Mobile Base System on ISS Truss
- Kibo External Facility (JAXA)
  - 32.5 ft 6 DoF Remote Manipulator System
  - 6.2 ft Small Fine Arm
- European Robotic Arm (ESA)
  - Stowed on orbit, to be installed on Multipurpose Laboratory Module (RSM) in 2013

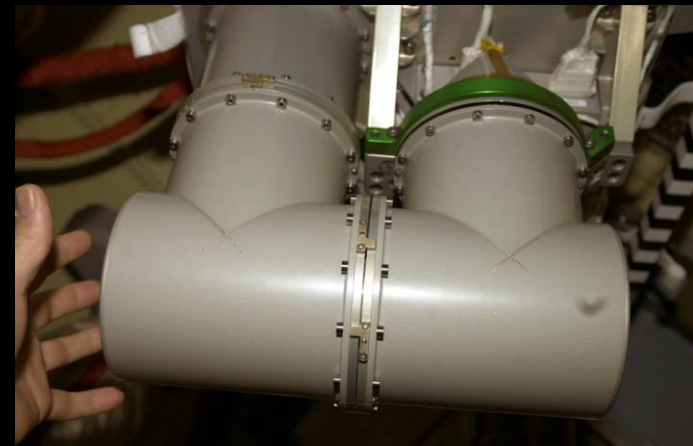


# Robotics Research and Technology Demonstrations



## Robotic Component Verification on the ISS (ROKVISS)

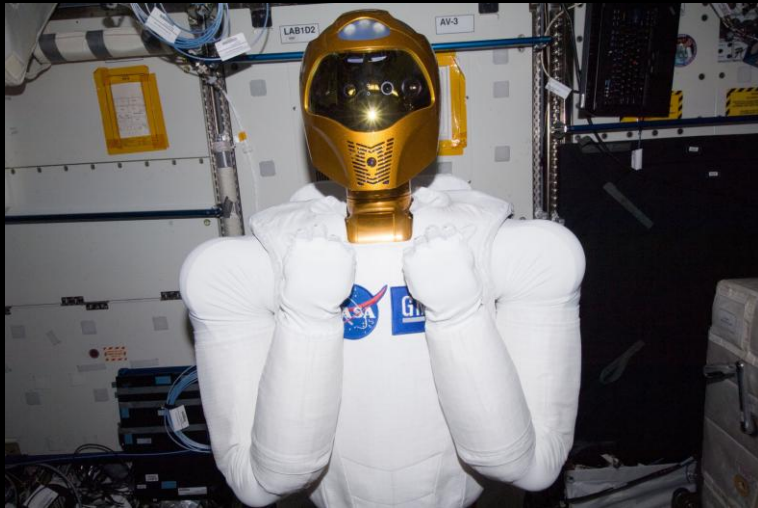
20 inch, 2 joint robotic  
element installed in 2005 on  
the exterior of Zvezda to  
demonstrate integrated light  
weight hinge elements and  
telerobotic control procedures



Joint Roscosmos /DLR project

Returned to ground in 2011

# Robonaut 2



Robonaut 2 is the first anthropomorphic ISS crew member. Designed to demonstrate humanoid robotic technology and applications to assist human crew members on future exploration missions.

Joint NASA/General Motors project

# Synchronous Position Hold Engage Reorient Experimental Satellites (SPHERES)



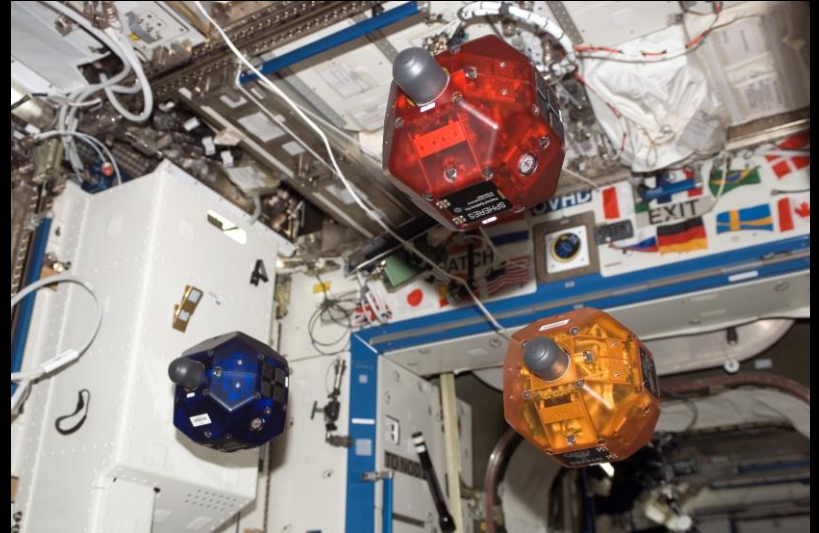
3 bowling ball sized free-flying satellites inside the pressurized ISS provides the opportunity to develop and test and iterate multi-body formation flying algorithms and concepts.

Originally a DARPA/MIT/Aurora Flight Sciences development, SPHERES is now managed by NASA ARC as an ISS facility.

|                            |                                |
|----------------------------|--------------------------------|
| Diameter                   | 8 inches each                  |
| Mass                       | 7 pounds each                  |
| Power                      | AA batteries                   |
| Propulsion                 | CO <sub>2</sub> gas            |
| Communications and Control | 900 MHz link to onboard laptop |
| Position knowledge         | 5 infrared/ultrasound beacons  |
| Crew                       | setup/monitoring/stow          |
| First launch               | 2006                           |



# International Space Station SPHERES Integrated Research Experiments (InSPIRE)



- DARPA/NASA follow-on to SPHERES
  - Advanced satellite R&D using SPHERES
  - Mods for ISS wifi compatibility
  - STEM Education
- 2010 DARPA BAA
  - Vision Based Navigation with addition of stereo cameras for 3-D inspection (MIT/Aurora Flight Sciences/NRL/Lockheed-Martin)
  - Electromagnetic Formation Flight/Coupled Power Transfer (Univ. of Maryland/Aurora Flight Sciences/MIT)
  - Exo-SPHERES concept study (Univ. of Maryland)





# Zero Robotics

## NASA/DARPA/MIT

- InSPIRE competition for high school students using SPHERES on ISS based on FIRST Robotics
- Student develop algorithms and flight code for a set test objective
- Code tested in space with students interacting with crew on ISS

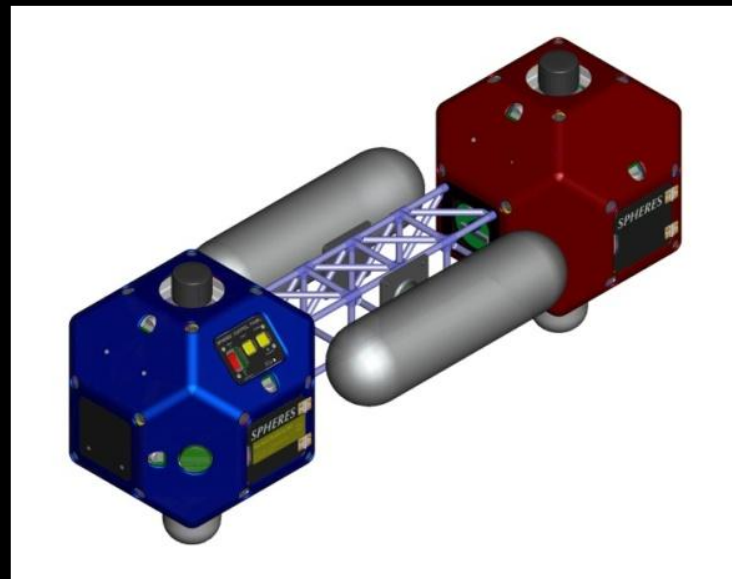


- Initiated with pilot program in 2009
- 142 teams (24 international) participated in 2011
- Over 200 students (27 teams) attended finals held in Jan 2012 at MIT with an additional 9 teams participating at ESA/ESTEC



# SPHERES SLOSH

- Uses SPHERES to study spacecraft propellant fluid dynamics
- 2 transparent tanks containing simulated propellant
- OCT funded, KSC lead



# Robotic Refueling Mission (RRM)

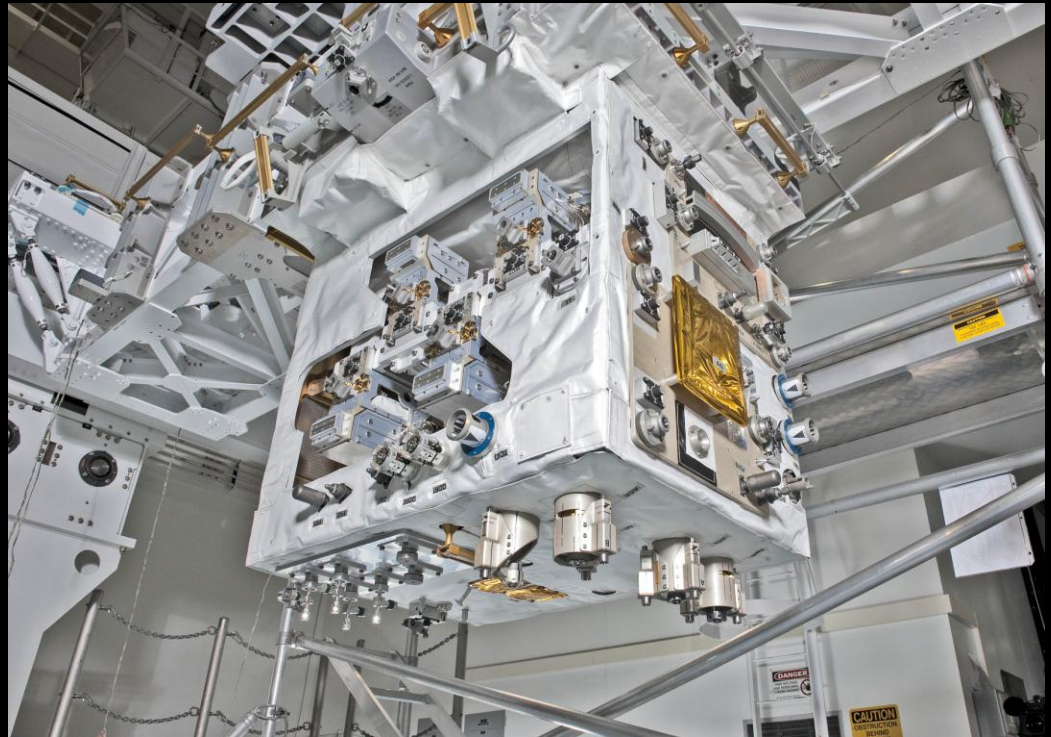


- Launched to ISS on STS-135 (July 2011)
- Joint NASA/CSA effort
- Demonstrates capability for telerobotic servicing of legacy spacecraft
- Uses Dextre with Goddard developed tools and task boards

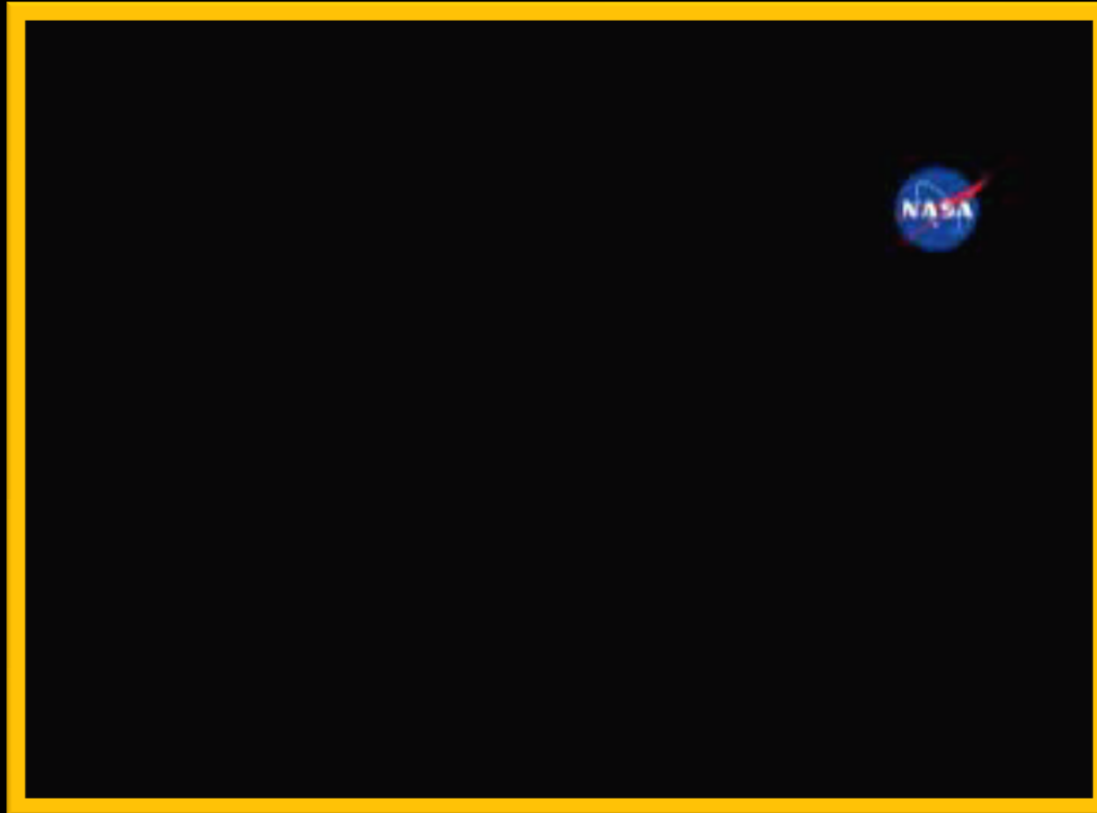
# RRM Tools and Task Boards



- Task boards simulate legacy spacecraft not designed for on-orbit servicing
- Fill & drain valves configured to replicate satellite close-outs
- Refueling transfer of representative fluid
- MLI cutting and manipulation
- Opening coolant valves
- Removing SMA caps
- Torque tasks
- Vision tasks



# RRM Video

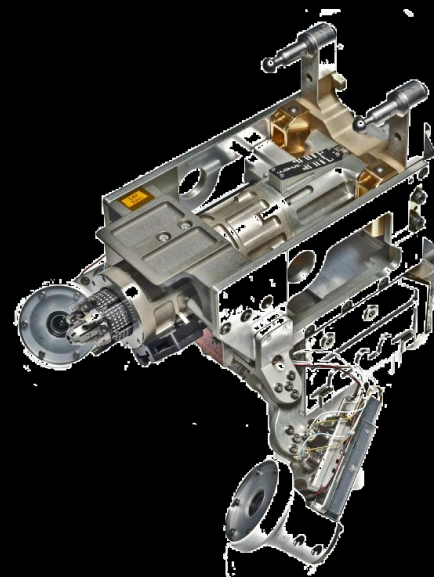




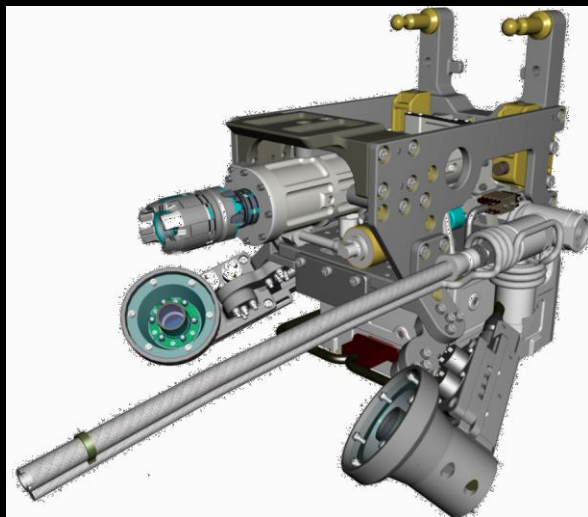
# RRM Tools



**Safety Cap Tool (SCT)**



**Multi-Function Tool (MFT)**

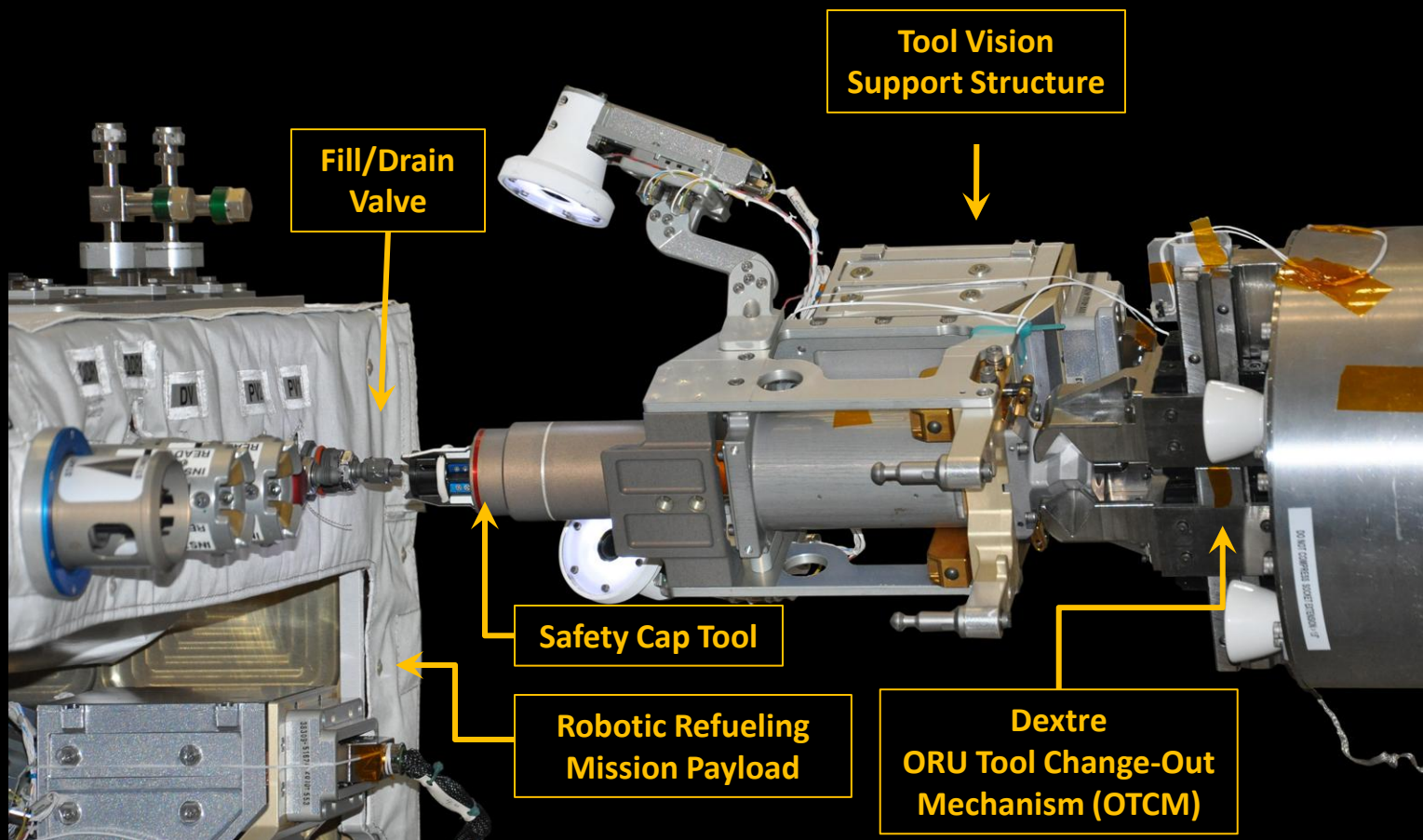


**EVR Nozzle Tool (ENT)**  
*For Spacecraft Refueling*



**Wire Cutter Tool (WCT)**

# RRM Tools

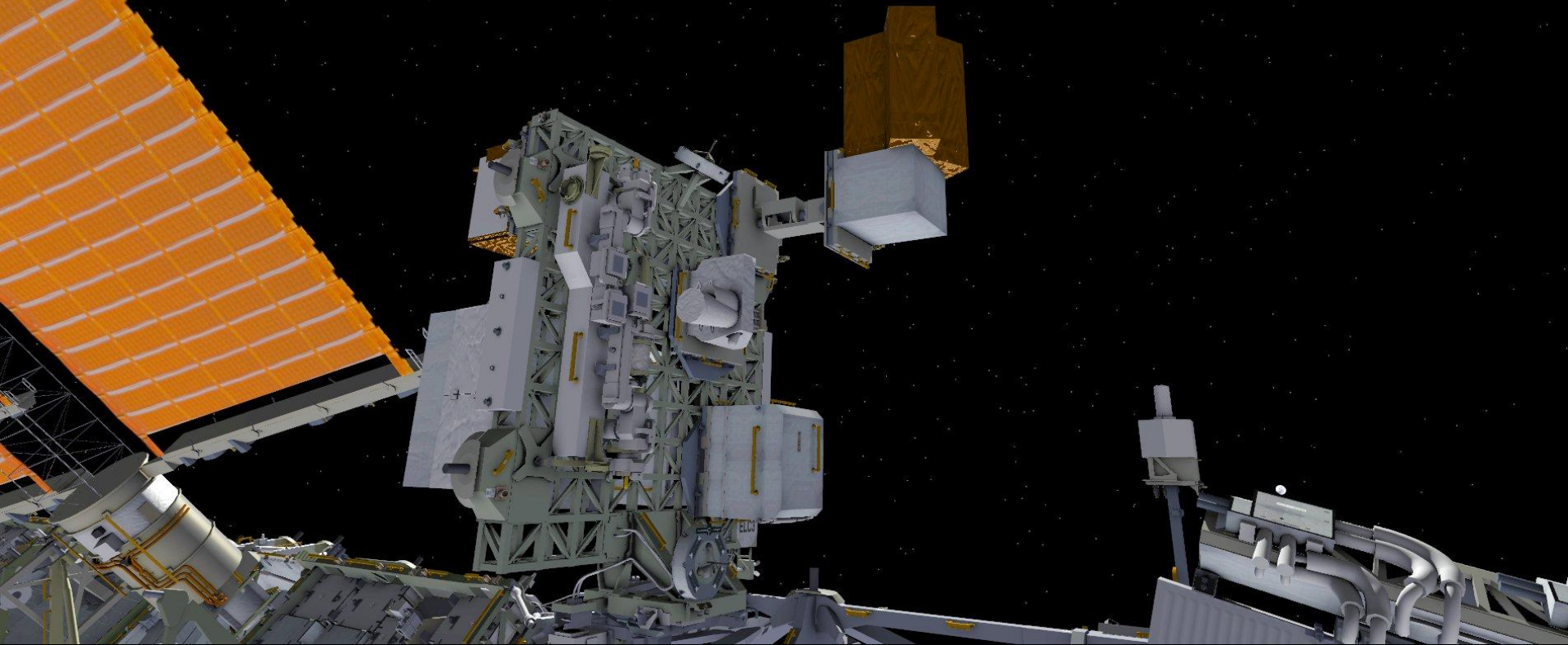


# Future Concepts

## Optical Testbed and Integration on ISS Experiment (OPTIIX)

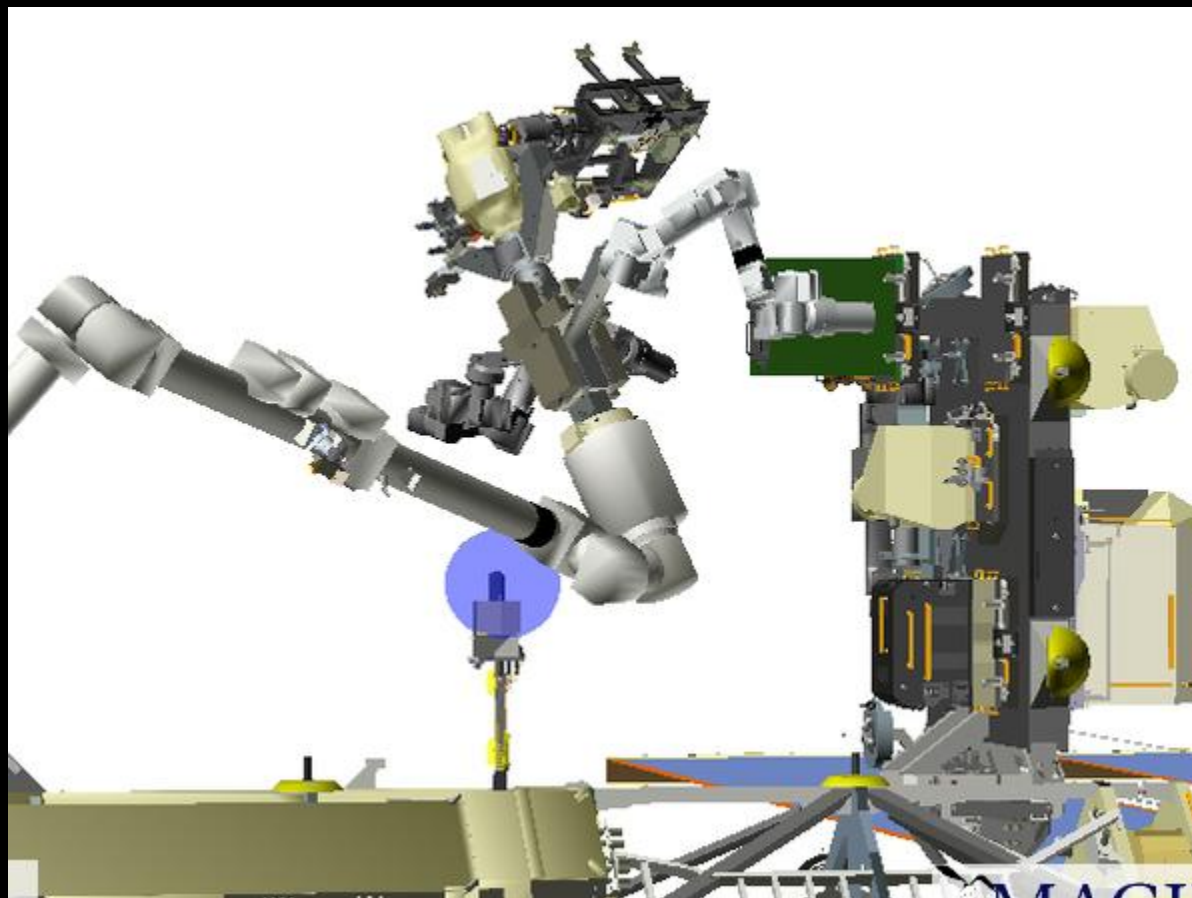


Develop tools and techniques for future in-space human/robotic assembly of large segmented aperture optical astronomical telescope





# OPTIIX





# InSPIRE Exo-SPHERES

Concept designs  
for small external  
free-flying  
satellite capable  
of providing  
inspection and  
EVA astronaut  
assistance

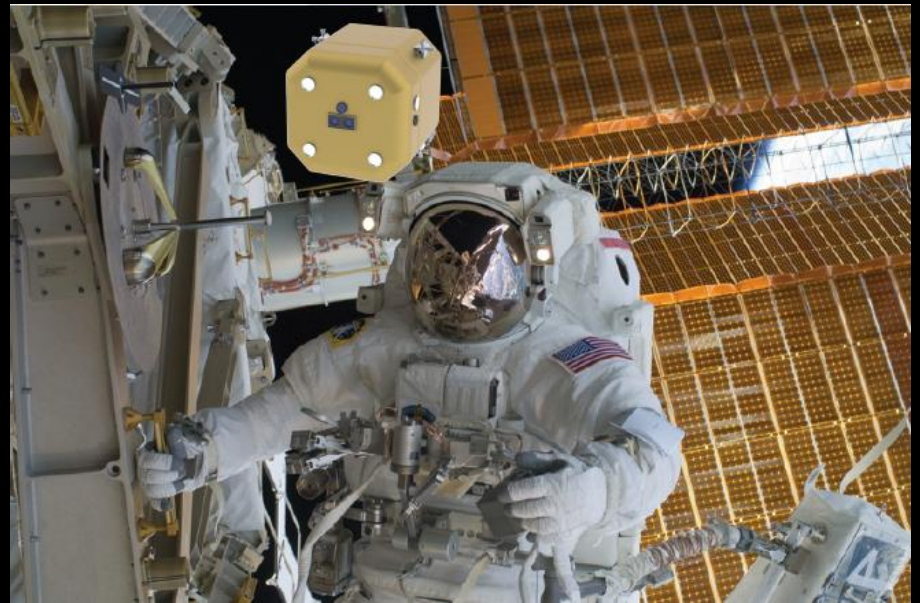


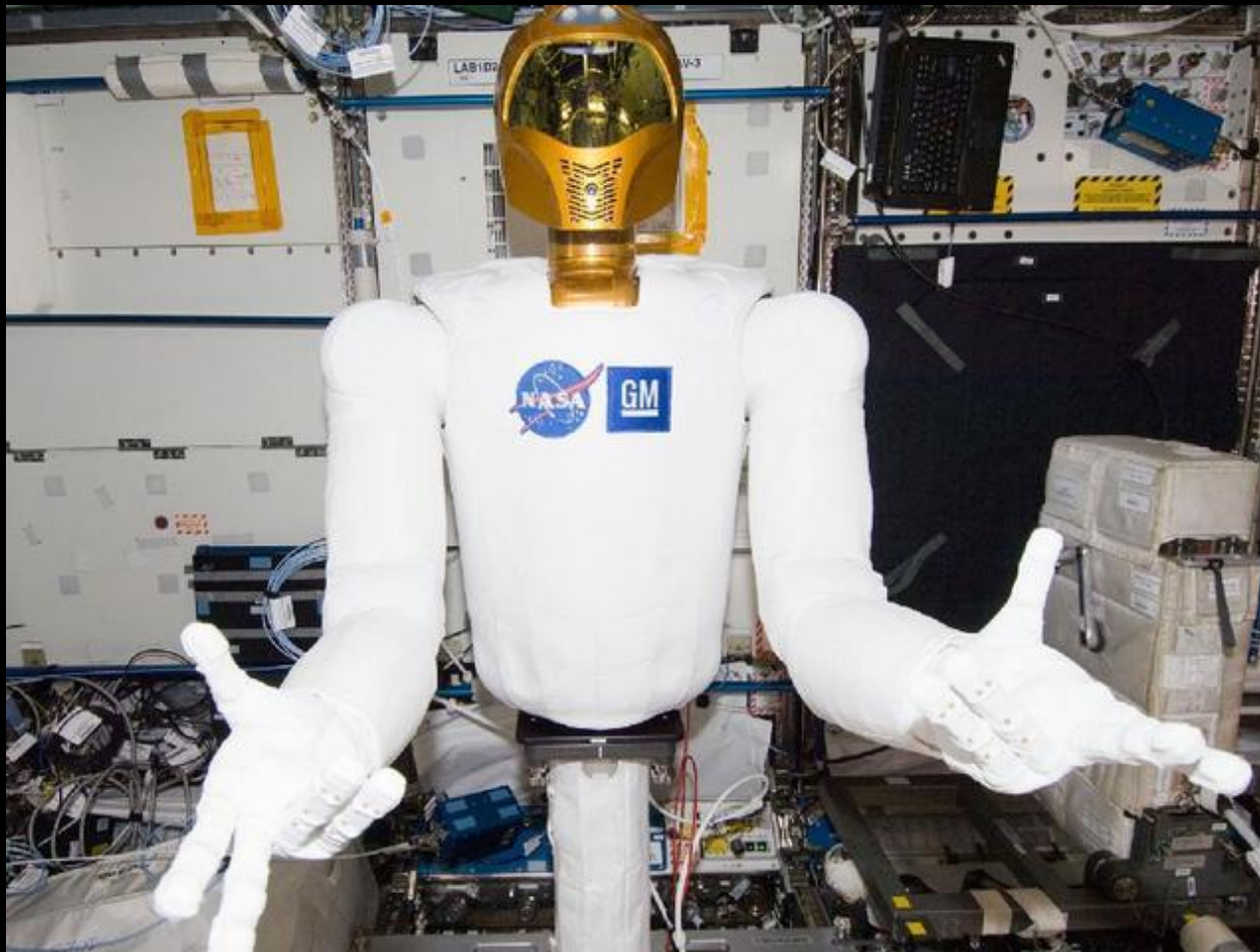
Image courtesy University of Maryland Space Systems Laboratory

# Future Human/Robotic Collaboration





# “Hello World”



ISS Robotics is moving forward for operations, exploration, science, commerce and education